SPECIALIZED SAMPLING
USING 3M MEMBRANE TECHNOLOGY

TECHNOLOGY DESCRIPTION

Since 1989, Minnesota Mining and Manufacturing Co. (3M) has incorporated state-of-the-art solid-phase extraction (SPE) technology into commercial membrane products for analytical sample preparation. 3M Empore™ High Performance Extraction Disks have become the SPE industry standard for meeting or exceeding U.S. Environmental Protection Agency (EPA) requirements for water analysis. Recently, disks have been introduced to capture and analyze radionuclides as well, including cesium-137, strontium-90, radium-226, and technetium-99. These Rad Disks utilize various classes of adsorbing particles loaded into a membrane, greatly simplifying and economizing radiometric sampling and analysis. Traditional sample preparation steps–such as lengthy precipitations, column extractions/elutions, and related pre-concentration processes–are eliminated, as is the need to transport bulky liquid samples. Furthermore, once the Rad Disks are loaded, they are placed directly onto planchets or into liquid-scintillation vials for radiometric counting.

To adapt these disks to field use, they are available in Rapid Liquid Sampler (RLS) form, which is a rugged, color-coded, disposable plastic holder. The RLS readily adapts Rad Disks to commercially available field-use devices, such as the Isco field sampler and 3M attended field sampler. Currently, 3M is evaluating the potential of commercially available portable counting instruments for direct Rad Disk field analysis.

Although this project is focused upon furthering analytical applications, 3M is also addressing large-scale remediation efforts through a similar technology for other U.S. Department of Energy (DOE) customers.

TECHNOLOGY NEED

The need to rapidly and economically identify hazardous materials and characterize their distribution, particularly on-site, is quickly growing in the DOE complex as activities increase to remediate contaminated sites, treat stored waste, and decontaminate facilities. The DOE spends an estimated $300 million annually to process over one million analytical samples in support of environmental management at approximately 4,000 sites. With processing costs divided roughly among collection, transportation, and laboratory analysis, significant savings can be realized by streamlining any or all of these processes. In addition to the need to manage the total cost of sample collection and analysis, there is a desire to evaluate more samples per site for improved characterization and decision-making.

The Site Technology Coordination Group (STCG) Needs numbers and titles are as follows:

OH-F004 - Technetium-99 Detector/Analyzer.
CH-SS01-99 - Remediation of Strontium-90 Contaminated Groundwater.
CH-SS03-99 - Treatment of Radioactive Contaminated Soils.
CH-SS04-99 - Long-Term Groundwater Monitoring.
ID-6.1.02 - Real-Time Field Instrumentation for Characterization and Monitoring of Soil and Groundwater.

TECHNOLOGY BENEFITS

This technology supports DOE remediation efforts, directly improving public safety and the environment. Using input from site personnel, sampling and analysis needs have been identified and incorporated into the overall design and performance specifications for Empore™ disks and RLS. From the results to date, DOE can expect to realize the following benefits based on the successful implementation of the RLS/field sampler:

The Empore™ Portable Sampling System fits into the carrying case at right. It uses Rad Disks containing special filter membranes that indicate when radioactive contaminants are present in the water flowing through the sampler membrane.

Rapid Deployment of User Friendly New Technologies

- Increased productivity through higher sample throughput.
- Greatly improved sample turnaround–from weeks to days or hours, by virtually eliminating sample preparation steps.
- Increased analytical accuracy and precision.
- Efficient sampling (greater than 95 percent of analyte retained).
- Minimization of analytical interferences through selective analyte capture.
- Convenient achievement of lower detection limits.
- Reduced costs in sample handling and analyses.
- Field-readiness: RLS/field sampler is rugged, compact, and battery-powered.

TECHNOLOGY CAPABILITIES/LIMITATIONS

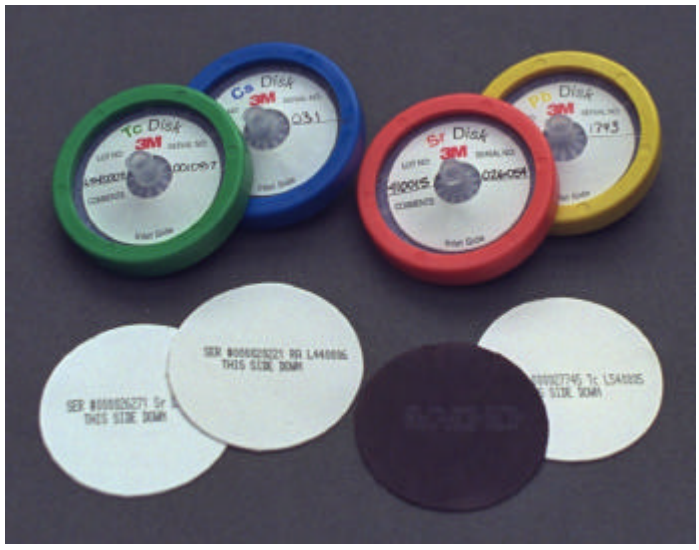
The RLS is designed for aqueous solutions relatively free of suspended solids. Prefiltration may be required to maintain rapid flow rates.

It seems likely that regulators, such as the EPA, will approve the new field sampling technologies. The EPA has accepted several methods for water analysis that employ 3M membranes, and regulators helped define technical performance specifications for this project. This Quality for Deployment (QFD) procedure greatly supports the program.

COLLABORATIONS/TECHNOLOGY TRANSFER

As part of the commercialization process, the technology was demonstrated in the field with technicians being trained on the use and benefits of the field sampler. Throughout the deployment activities, several partnerships were developed with DOE, the national laboratories, and representatives of the various sites of concern to ensure that the needs of the sites, regulators, and end-users were met.

One area of commercial deployment identified is time-weighted remote sampling. A field study has been initiated between Savannah River Site (SRS), Isco, and 3M to combine the RLS and Isco composite sampler. A widely used technology, approximately 50,000 Isco samplers are in use worldwide, with more than 100 actively sampling at SRS. The results are extremely promising, accomplished through several cost-sharing agreements. SRS technical personnel have presented field sampling data using 3M Rad Disks on numerous occasions.



Exploded View of Rapid Liquid Sampler (RLS) Components

ACCOMPLISHMENTS AND ONGOING WORK

Technetium and lead were chosen as the initial demonstration analytes. RLS components for these disks were fabricated and demonstrated in a prototype sampling system. Demonstrations were performed at four sites in 1997: Paducah, Kentucky; Savannah River, South Carolina; West Valley, New York; and Morris, Illinois. Improvements in the system stimulated by each use were implemented in the next demonstration. Data collected showed comparable results between the disk and baseline methods. On-site analysis techniques using disk color development and portable self-indicating membranes were initiated in laboratory studies. More recent developments have produced disks for cesium-137, strontium-90, and radium-226 in 1998 and 1999. A demonstration at Ashtabula, Ohio, is planned for this year. Also this year, a Generation II RLS design that is easier to open will be introduced.

The commercialization/deployment plans consist of several important milestones: move baseline laboratory technology into the field (on-site); incorporate end-user interaction throughout the development process; identify and understand user value; establish parameter performance targets; and prepare submittals for regulatory acceptance.

Many sites, such as Savannah River, South Carolina, are currently using the commercially available Rad Disks for routine analyses and have readily accepted the concept of incorporating the RLS into their sampling/monitoring programs. Since Rad Disks already exist for separating cesium-137, strontium-90, radium-226, and technetium-99, the implementation discussions with end-users held during the development tasks have been accomplished with a minimal amount of effort.

Based on the results obtained during Phase I of the program, significant advantages of the 3M Empore™ selective separation technology translate into direct economic benefits. A cost benefits analysis summary for Rad Disks has been developed. Another cost benefit analysis on the RLS is planned.

Awards received for the technology developed under this program include the Industrial Research and Development 100 Award in 1996 and the Federal Laboratory Consortium Award in 1997. Major publications were completed, and papers were presented during the development of the field sampling technology.

Empore™ Rad Disk Publications and Presentations

- M.P. Pendl and L.A. Schreiner, "An Evaluation of Solid Phase Extraction Disks for the Routine Analysis of Strontium-90 in Water by an On-Site West Valley Demonstration Project Laboratory," 44th *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1998.

- R.T. Preston and A.H. Mohagheghi, "Determination of Sr-90 in Urine by Empore™ Rad Disks," 44th *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1998.

- V. Lopez-Avila (Editor-in-Chief), "Radiostrontium Analysis Using Sorbent Disks," *Current Protocols in Field Analytical Chemistry*, Wiley & Sons, Inc, pp. 4A.1.1-4A.1.8, 1998.

- D.C. Seely and J.A. Osterheim, "Radiochemical Analyses Using Empore™ Disk Technology*," Journal of Radioanalytical and Nuclear Chemistry*, Vol. 236, Nos. 1-2, pp. 175-180, 1998.

- D.M. Beals, W.G. Britt, J.P. Bibler, and D.A. Brooks, "Radionuclide Analysis Using Solid Phase Extraction Disks," *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 236, Nos. 1-2, pp. 187-191, 1998.

- A. Durecova, "Contribution to the Simultaneous Determination of Ra-228 and Ra-226 by using 3M's Empore™ Radium Rad Disks," *Journal of Radioanalytical and Nuclear Chemistry*, Vol. 223, Nos. 1-2, pp. 225-8, 1997.

- S.C. Goheen, editor, DOE Methods for Evaluating Environmental and Waste Management Samples, Battelle Press, Columbus, OH, "Method RP515, Rapid Determination of Radiostrontium Using Empore™ Strontium Rad Disks," 1997.

- S.C. Goheen, editor, DOE Methods for Evaluating Environmental and Waste Management Samples, Battelle Press, Columbus, OH, "Method RS551, Rapid Isolation and Measurement of Technetium-99 Using 3M Empore™ Technetium Rad Disk," 1997.

- S. Scarpitta, J. Odin-McCabe, R. Gaschott, A. Meier, and E. Klug, "Comparative Results of Four Sr-90 Groundwater Analytical Methods," 43rd *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1997.

- E.R. Gonzales and R. Robinson, "Determination of Sr-90 in Environmental Samples using Empore™ Rad Disks," 42nd *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1996.

- S.C. Scarpitta and P.W. Miller, "Liquid Scintillation Counting as a Research Tool in Evaluating 3M's Empore™ Radium Disks," 42nd *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1996.

- S.C. Scarpitta and P.W. Miller, "Evaluation of 3M's Empore™ Rad Disks for Radium in Water," 42nd *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1996.

- L.L. Smith, K.A. Orlandini, M.D. Erickson, J.S. Crain, J.S. Alvarado, and J.H. Aldstadt, "Faster, Cheaper Radioanalytical Methods," PittCon, 1996.

- L.L. Smith, K.A. Orlandini, J.S. Alvarado, D.C. Seely, and K.M. Hoffmann, "Application of Empore™ Disk Technology to Environmental Radiochemical Analysis," 41st *Annual Bioassay*, Analytical and Environmental Radiochemistry Conference, 1995.

Empore™ Rad Disk Patent Work

- U.S. Patent Application, "Self-Scintillating Sheet Material for Radioactive Species Analysis," submitted 1997.

- U.S. Patent Application, "Method for the Colorimetric Quantification of Ions in a Solution Using Ion Recognition Substrates Enmeshed in a Porous Matrix or Membrane," submitted 1996.

- U.S. Patent Number 5,637,506, "Solid Phase Extraction Using Composite Sheet for Direct Measurement of Radioactivity."

TECHNICAL TASK PLAN (TTP) INFORMATION

TTP No./Title: FT06C261 - Specialized Sampling and Separations Using 3M Membrane Technology.

Earlier work by Argonne National Laboratory supporting the project was performed under TTP No. CH27C221.

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